Tutorial Proposal for SoutheastCon 2022

Tutorial information

Title: RFID-based Sensing: from Vital Sign Monitoring to 3D Pose Estimation
Instructor: Shiwen Mao, Auburn University, Auburn, AL

Abstract (limit 500 words)

This tutorial covers the application of RFID-based sensing with its application to human vital sign monitoring and 3D human pose estimation. This is an interdisciplinary area and a good match to SoutheastCon 2022's areas of interest: Communications & Electromagnetics, Computing Systems, Signal Processing, Microelectronics, Devices & Sensors, Artificial Intelligence & Predictive Modeling.

The *first part* of this tutorial is focused on RFID-based human vital sign monitoring and its application to driving fatigue detection. With the rapid development of intelligent health sensing in the Internet of Things (IoT), vital sign monitoring (e.g., respiration) and abnormal respiration detection have attracted increasing attention. Considering the challenges and the cost of collecting labeled training data from patients with breathing related diseases, we develop the AutoTag system, an unsupervised recurrent variational autoencoder-based method for respiration rate estimation and abnormal breathing detection with off-the-shelf RFID tags and reader. Moreover, for real-time breath monitoring, a novel method is proposed to cancel the distortion on measured phase values caused by channel hopping for FCC-complaint RFID systems. We will also show how to apply RFID based sensing for an effective, low-cost driving fatigue detection system, such as detecting the nodding movements or the respiration rate of the driver, both in the highly noisy driving environment. The accurate detection performance of the proposed systems is validated by our experimental study.

The *second part* of this tutorial will be focused on 3D human pose tracking, an important topic in computer vision (CV). To protect user privacy, there is considerable interest in techniques without using a video camera. To this end, RFID tags, as a low-cost wearable sensor, provide an effective solution for 3D human pose tracking. In the second part of this tutorial, we first present RFID-Pose, a vision-aided realtime 3D human pose estimation system based on deep learning. The RFID phase data is calibrated to effectively mitigate the severe phase distortion, and High Accuracy Low Rank Tensor Completion (HaLRTC) is employed to impute missing RFID samples. The system then estimates the spatial rotation angle of each human limb, and utilizes the rotation angles to reconstruct human pose in realtime with the forward kinematic technique. We next address the user adaptation problem, when a well-trained system is used to monitor the 3D pose of a new subject. We propose Cycle-Pose, a user-adaptive realtime 3D human pose estimation system. A cycle kinematic network is proposed to remove the restriction in pairing RFID and vision data for training. The resulting system is user-adaptive, achieved by learning to transform the RFID data into a human skeleton for different subjects. The third part addresses the environment adaptation problem, when a well-trained system is applied in a new environment. Meta-learning, as an effective technique to improve the model adaptability, is leveraged as a promising solution to the generalization problem. We develop an RFID based pose estimation system, termed Meta-Pose, which is based on the meta-learning framework to address the generalization problem. The three systems are prototyped with commodity RFID devices and validated with extensive experiments, where high pose estimation accuracy and realtime operation are demonstrated.

Outline of the tutorial

(1) Background, motivation, and preliminaries
(2) Respiration Monitoring and Apnea Detection

(3) Respiration Monitoring in Driving Environments
(4) Human Pose Tracking: Preliminaries and Existing Approaches
(5) RFID-Pose: 3-D Human Pose Generation from RFID Data
(6) Cycle-Pose: Dealing with Subject Adaptability
(7) Meta-Pose: Adaptation to Different Data Domains
(8) Open Problems and Conclusions

Proposed length of the tutorial

I am flexible; either 2 or 3 hours will be good.

Resume of the instructor

Shiwen Mao received his BE and ME, both in Electronic Engineering, from Tsinghua University, Beijing, China in 1994 and 1997, respectively. He also received a BEc in Enterprise Management from Tsinghua University in 1994 and an MS in Systems Engineering from Polytechnic University (now NYU Tandon School of Engineering), Brooklyn, NY, in 2000. He received a Ph.D. in Electrical Engineering from Polytechnic University in 2004. He was a Postdoctoral Research Associate and then a Research Scientist in the Bradley Department of Electrical and Computer Engineering at Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, VA from 2003 to 2006. In 2006, he joined Auburn University, Auburn, AL as an Assistant Professor in the Department of Electrical and Computer Engineering. He held the McWane Endowed Professorship from 2012 to 2015 and the Samuel Ginn Endowed Professorship from 2015 to 2020. Currently, he is a Professor and Earle C. Williams Eminent Scholar Chair, and Director of the Wireless Engineering Research and Education Center (WEREC) at Auburn University.

Dr. Mao's research interest includes wireless networks, multimedia communications, and smart grid. He is a Distinguished Lecturer of IEEE Communications Society (2021-2022) and IEEE Council of RFID (2021-2022), and a Distinguished Lecturer (2014-2018) and a Distinguished Speaker of IEEE Vehicular Technology Society (2018-2021). He received the IEEE ComSoc TC-CSR Distinguished Technical Achievement Award in 2019, the IEEE ComSoc MMTC Distinguished Service Award in 2019, the Auburn University Creative Research & Scholarship Award in 2018, the 2017 IEEE ComSoc ITC Outstanding Service Award, the 2015 IEEE ComSoc TC-CSR Distinguished Service Award, the 2013 IEEE ComSoc MMTC Outstanding Leadership Award, and the NSF CAREER Award in 2010. He is a co-recipient of the 2021 IEEE Communications Society Outstanding Paper Award, the IEEE Vehicular Technology Society 2020 Jack Neubauer Memorial Award, the 2018 IEEE ComSoc MMTC Best Journal Paper Award, the 2017 IEEE MMTC Best Conference Paper Award, IEEE SECON 2017 Best Demo Award, Best Paper Awards from IEEE GLOBECOM 2019, IEEE GLOBECOM 2016, IEEE GLOBECOM 2015, IEEE WCNC 2015, and IEEE ICC 2013, and the 2004 IEEE Communications Society Leonard G. Abraham Prize in the Field of Communications Systems. He is an Associate Editor-in-Chief of IEEE/CIC China Communications, an Area Editor of IEEE Transactions on Wireless Communications, IEEE Internet of Things Journal, IEEE Open Journal of the Communications Society, and ACM GetMobile, and an Associate Editor of IEEE Transactions on Cognitive Communications and Networking, IEEE Transactions on Network Science and Engineering, IEEE Transactions on Mobile Computing, IEEE Multimedia, IEEE Network, and IEEE Networking Letters, among others. He is the General Chair of IEEE INFOCOM 2022 and TPC Chair of IEEE INFOCOM 2018, and the TPC Vice-Chair of IEEE GLOBECOM 2022. He is a Fellow of the IEEE, a member of the ACM and the IET.

For more details, see: https://www.eng.auburn.edu/~szm0001/

Budget including fees to be requested from attendees and required by instructor

It would be nice if the travel expense of the instructor can be covered (e.g., lodging and/or mileage)